MAI-2003-05

UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
Metal and Nonmetal Mine Safety and Health

REPORT OF INVESTIGATION

Underground Nonmetal Mine
(Limestone)

Fatal Machinery Accident
March 24, 2003

JS&G Underground Mine #1
Joliet Sand & Gravel Company
Joliet, Will County, Illinois
Mine I.D. No. 11-03084

Investigators

Fred H. Tisdale
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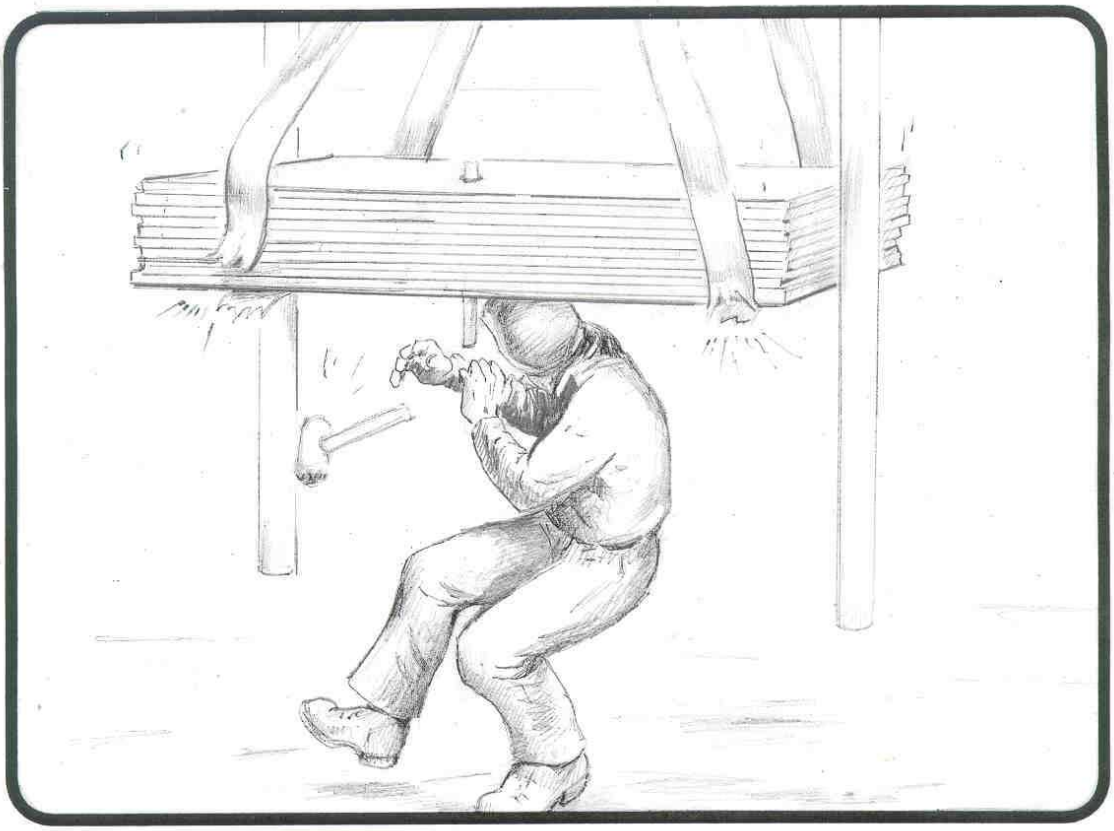

OVERVIEW

On March 24, 2003, James G. Carey, surface foreman, age 46, was fatally injured when he was struck by a conveyor belt counterweight that was being installed. A crane was lifting steel plates that were to be used as the counterweights. The victim was positioning the plates when the rigging failed and the plates crushed him.

The accident occurred because the procedures used to install the counterweight were inadequate. When the connecting rod failed to align with the holes in the support frame cross-member, the victim positioned himself under the suspended counterweight to drive the rod into position. The nylon rigging straps, used to lift the steel counterweight, became damaged on the sharp edges of the plates. The damaged rigging then failed and the counterweight fell.

GENERAL INFORMATION

JS&G Underground Mine #1, a limestone operation owned and operated by Joliet Sand & Gravel Company, was located in Joliet, Will County, Illinois. The principal operating officials were George Comerford, Jr., president; and Robert Archibald, vice president. The mine was normally operated three, 8-hour shifts, six days a week. Total mine employment was 28 persons.

Limestone was mined underground using the room and pillar method. Headings were drilled, blasted, and loaded into haul trucks with front-end loaders. The trucks hauled the rock to the primary crusher underground. The crushed rock was conveyed to surface via the decline conveyor belt and further processed at the mill, where it was sized, stockpiled and sold for construction aggregate.

The last regular inspection at this operation was completed February 6, 2003. Another inspection was conducted following this investigation.

DESCRIPTION OF THE ACCIDENT

On the day of the accident, James G. Carey, surface foreman (victim), reported for work at 7:00 a.m., his normal starting time. Michael H. Campbell, crane operator; Kevin Appleton, maintenance; and William Ferguson, maintenance; were the surface crew and Carey was their supervisor.

The surface crew went about normal maintenance duties until lunchtime, when they learned that a belt splicing crew had finished splicing the decline conveyor belt. After finishing their lunch, the surface crew traveled to the area of the decline conveyor belt take-up pulley to install a new counterweight system.

The crew arrived at the decline conveyor take-up system and started assembling the counterweight on top of two concrete blocks that were positioned directly under the take-up pulley. The counterweight consisted of 14 steel plates designed to be held together and attached to the take-up pulley with three threaded steel rods.

Carey calculated the load and selected two nylon web straps to attach to the plates. The straps were 12 feet long, 2 inches wide, and were rated for 12,800 pounds each in a basket configuration, which was used. Reportedly, the straps were new and were removed from their packaging and Carey positioned them around the plates. The straps were then attached to chains, already in place, which in turn attached to steel cable slings hung from a crane. Carey then directed Campbell to lift the load. After several attempts to line up the three bolts with their respective holes in the take-up pulley frame, Carey directed Campbell to lower the counterweight on the concrete blocks. Carey then repositioned the straps. One of the end bolts was removed and the other had dropped out. It was thought that it would be easier to thread the center bolt, attach the nut, then

install the other two bolts. The crane operator was again directed to raise the weight.

As the counterweight plates were lifted into position, Appleton, who was working from a manlift basket above the take-up pulley frame, was to install the nuts. When the hanger bolt would not go through the frame, Carey moved underneath the counterweight and used a sledgehammer to drive the bolt through. During this activity, the nylon slings failed and the counterweight struck Carey.

Campbell, Ferguson, and Appleton ran to aid Carey and 911 was called. Emergency personnel arrived and, because of the massive head trauma, they called the county coroner who arrived and pronounced the victim dead at 5:29 p.m.

INVESTIGATION OF THE ACCIDENT

MSHA was notified of the accident at 6:05 p.m. on March 24, 2003, by a telephone call from Dan Foltyniewicz, risk manager, to Steven Richetta, assistant district manager. An investigation was started the next day. An order was issued pursuant to section 103(k) of the mine act to ensure the safety of miners.

An MSHA accident investigation team conducted a physical inspection of the accident scene, interviewed employees, and reviewed conditions and work procedures relevant to the accident. MSHA conducted the investigation with the assistance of mine management and employees.

DISCUSSION

Decline Conveyor

Crushed limestone of minus 10-inch size was conveyed from the primary crusher underground to the surface by a series of conveyor belts. Sequentially, the material left the crusher on a short belt that dumped onto the transfer conveyor belt. At the end of the transfer belt, the material dumped onto a decline conveyor belt. The 1,100-foot-long decline conveyor belt transported the crushed limestone upgrade from the mine into the quarry pit to a transfer point, where it then dropped through a chute onto a stacker conveyor belt. The material was conveyed further upgrade and was then dumped onto a surge pile. The accident occurred on the surface at the head end of the decline conveyor belt beneath the take-up pulley counterweight frame. The frame was approximately 12 feet north of the belt drive pulley.

The decline conveyor belt was manufactured by American Bin and Conveyor, Incorporated. It was Model No. 48x1021, and had Serial No. 02-001. This belt was first used on November 22, 2002, and was last used on December 20, 2002. Its total usage was 222 hours prior to the accident. The 48-inch wide belt was

supported by a steel truss structure that was 44 inches deep and 60 inches wide. It consisted of angle-shaped members that made up the bottom chords, top chords, and diagonals. The top and bottom chord angles were 3-inch by 4-inch by 1/4-inch. The diagonal angles were 2-inch by 2-inch by 1/4-inch.

Due to operational problems with the decline conveyor, the company consulted with the manufacturer and determined that the problems could be remedied by replacing the original dual counterweight system with a single unit system. The manufacturer agreed to provide a new retrofit counterweight frame, mounts, and a guide system. Joliet Sand and Gravel was responsible for installing the new system and for providing the steel plates and rods, which would serve as the counterweight. In the week prior to the accident, the belt was cut; the original counterweight was removed; and the new mounts, guide tubes, and frame were installed. The belt was fed through the new counterweight frame, which at the time did not include the stack of 14 plates. To provide a method of tensioning the newly shortened belt, a small angle was temporarily welded to each circular guide tube to act as stoppers. On the day of the accident, the empty take-up frame was lifted up against the guide stoppers while the contractor spliced the shortened belt. The accident occurred when the mine workers were attempting to attach the stack of plates to the new elevated counterweight frame.

The counterweight was composed of 14, one-inch-thick, ASTM A36 steel plates. The plates measured 46-3/4 inches wide by 72 inches long and weighed 955 pounds each. The combined stack weight was 13,370 pounds. There were three, 1-5/8 inch diameter holes in each plate, through which three threaded rods were to be used to connect the stacked plates to the counterweight frame. The holes were aligned along the centerline of the plate, which was parallel to the plate's long dimension. The center of the middle hole was 36 inches from the edge of the plate, and the center of each outer hole was 4-1/8 inches from the edge of the plate. The bolts that were to be used to attach the weights to the counterweight frame were 1-1/2 inch diameter, 36-inch-long all-thread rods. The nuts were 2- 3/8 inches by 1-1/2 inches.

The plates were manufactured by Northern Illinois Steel Supply Company. According to the manufacturer, each plate was cut to size with a machine mounted cutting torch. A 4-1/2 inch diameter grinder wheel was then used to remove any slag or rough spots. The plate edges were at 90-degree angles to each other. There were no special provisions with this job to radius any of the plate corners.

The take-up pulley was mounted to the center of a rectangular frame that measured 81-3/4 inches wide and 52 inches high. The counterweight frame consisted of rectangular tube-shaped 7-inch by 5-inch by 3/8-inch top and bottom cross members and 5-inch by 5-inch by 3/8-inch vertical members, which fit over the 3-1/2-inch diameter circular slide tubes. The bottom cross member was predrilled with three holes for attaching the three threaded rods. Predrilled plates

measuring 8-inches by 5-inches by 1/2-inch were welded at the three hole locations along the bottom cross member.

Rigging

The bottom cross member of the counterweight frame was measured to be 96 inches from the ground. Two concrete blocks, 2-feet by 2-feet by 6-feet were stacked between the counterweight guide tubes. The steel plates were then stacked one at a time on top of the 48-inch high block platform prior to lifting them as a whole. Therefore, the 14-inch high stack of plates needed to be lifted approximately 34 inches in order to be bolted to the bottom cross member of the counterweight frame.

A P&H Model R-150 crane, Serial No. 33146, was used to lift the counterweight. It had an extending boom ranging in length from 24 feet to 60 feet and a maximum lifting capacity of 15 tons. The crane was positioned along the west side of the conveyor with its outriggers fully extended. The left front (northeast) outrigger was resting on two steel bearing plates to spread the load into a soft muddy area on the ground. For this lift, the crane's operating radius was 24-1/2 feet. According to the load chart posted on the crane, at this operating radius it had a capacity of 15,500 pounds. This capacity was limited by the stability of the crane against tipping; not its structural competence. The crane was not equipped with a load-indicating gauge.

Reportedly, the hoisting equipment consisted of a combination of wire ropes, chains, and synthetic nylon slings. Starting from the tip of the crane boom, a four-part line was connected to the crane block. A 5-inch by 10-inch master link from a four-leg wire rope bridle was looped over the crane hook. The four wire ropes were 5/8 inches in diameter and were 20 feet long. The hooks located at the end of each wire rope had a 10,000-pound working load limit. Two of the four wire ropes were strung down through the conveyor truss structure, while the other two wire ropes wrapped back up and were hooked onto the master link. With two wire ropes, the rated capacity was approximately 14,000 pounds. Two metal chains were then draped over the wire rope end hooks that hung down through the conveyor truss structure. The chains hung down around the take-up pulley, which was mounted to the counterweight frame. Each chain, which was made by ACCO, measured 16 feet long and had a 7,100-pound working load limit. In a basket lift configuration, similar to how it was draped over the wire rope hook, each chain had a capacity of 14,200 pounds. Finally, two nylon slings were wrapped around the counterweight plates in a basket configuration and attached to each chain hook.

Based on rub markings on the take-up pulley and on a diagonal (angle-shaped) brace in the top chord of the truss, it did not appear that it was a straight vertical pick up through the counterweight frame and truss. In addition, the boom tip of the crane was positioned approximately 1 foot to the west of the centerline of the

conveyor belt. This off-center alignment and interference may have caused a slightly unbalanced load to be applied to one of the nylon slings.

The nylon slings were of standard designation EE2-802, which was a 2-ply flat eye sling. They were manufactured by Indusco Wire Rope and Fittings. Each measured 12 feet long and had a 2-inch wide web. According the manufacturer's tag, each sling had a lifting capacity of 12,800 pounds when used in a basket configuration. Therefore, in a balanced lift, their combined capacity should have been 25,600 pounds. Reportedly, this was the first time the slings had been used. A warning tag on the slings indicated to avoid sharp edges and to protect the webbing from sharp edges. No measures were taken to protect the slings from the sharp corners of the steel plates.

Accident Scene

Kevin Appleton was assigned to work from a man lift basket platform. The man lift was a JLG Model 60H, with a 60-foot maximum reach and a 36-inch x 96-inch platform. Appleton's assignment was to place the nuts onto the threaded rods once they were fed up through the stack of plates and the lower counterweight frame cross member. Appleton was in the basket, which was positioned to the south of the counterweight frame, when the accident occurred.

The counterweight was lifted and suspended for at least 30 minutes while the victim attempted to feed the bolts up through the holes on the counterweight frame cross member. The steel plates were suspended in the air approximately 2 inches from the bottom of the cross member. The victim was under the counterweight using a sledgehammer to help drive the center bolt through the holes in the lower cross member, when the nylon slings suddenly failed. One end of the counterweight landed on the concrete blocks while the other end rested on the ground. According to a witness statement and the final position of the blocks, it appears that the west side nylon strap failed first.

During the recovery of the victim's body, the counterweight was moved and set entirely on the ground. The concrete blocks were also knocked over on their sides. The center bolt was found to be protruding approximately 17-1/2 inches from the top steel plate. The bolt was bent at a point about 3 inches from the top plate. The bottom 2 inches of the center bolt had been torched off and only one nut had been installed.

The top 6-3/4 inches of the threads on the center bolt were stripped when the plate stack fell. This dimension agreed exactly with the length of the threaded rod that would have penetrated the bottom tube of the counterweight frame. The distance from the lower outside face of the bottom tube to the inside face of the top of the bottom rectangular tube was 6-3/4 inches. A shiny mark was evident on the inside face of the top of the bottom rectangular tube. The shiny mark may have been caused by the victim hammering on the bolt to get it fed through the

upper hole, and/or it could have been caused by the crane placing upward lift pressure on the plates. If the protruding bolt was being pinched by the relative alignment of the various plates in the stack, it could have transmitted the upward lift force to the tip of the bolt and ultimately to the bottom rectangular tube.

Nylon Sling Evaluation

The two failed nylon straps were taken from the scene by the Will County Sheriff's Department. The custody of the slings was then transferred to MSHA for further evaluation on April 2, 2003. (See photograph of slings in Appendix C.)

One nylon sling was used to suspend the east side of the plates and the other strap was used to hold up the west side. The two pieces of the east side sling were referred to as the north and south pieces, respectively. The north piece was 70 inches long from the end of the eye loop to the break location. The break would have corresponded with the lower north corner of the basket configuration. The south piece was 75 inches long from the end of the eye loop to the break location. Approximately 32 inches from the eye loop of the south piece, there was a distinct abrasion area on the sling that appeared to be partly cut. This would have corresponded to the south corner of the basket configuration. Likewise, evidence of yellow abraded nylon sling fibers was found adhering to the lower south edge of the east side of the stack of plates.

The two pieces of the west side sling were also referred to as the north and south pieces, respectively. The north piece was 63-1/4 inches long from the end of the eye loop to the break location. The break corresponded with the contact location of the lower north corner of the basket configuration. The south piece was 82-1/2 inches long from the end of the eye loop to the break location. Approximately 40-1/2 inches from the eye loop on the south piece, there was a distinct abrasion area on the sling where it had started to be cut. This would have corresponded to the south corner of the basket configuration.

On April 23, 2003, an identical sling from the same manufacturer was tested at Safety Sling in Pittsburgh, Pennsylvania. The tension load to break the sling was nearly 32,000 pounds. This was at the expected factor of safety for a sling of this width. A direct pull test showed that a failure from tension overload is clearly different than the type of relatively abrupt tears that occurred when the slings were used around unprotected sharp plate corners on the day of the accident. The failure surface of the tested sling had no distinct edge and had considerably more fraying than the accident slings.

Training and Experience

The victim had 8 years mining experience, all at this mine. He had received training in accordance with 30 CFR, Part 48.

ROOT CAUSE ANALYSIS

Causal Factor – The nylon straps used to lift the steel plates were not protected from the sharp metal edges of the steel.

Corrective Action - Always refer to manufacturer's recommendations, hazard alerts and warnings. The nylon straps had labels stamped with warning to protect straps from sharp edges and rough loads.

Causal Factor – The victim was working under a suspended load.

Corrective Action – Procedures should be established to ensure suspended loads are properly supported prior to persons working under them. Management should review their safety program and implement a job task analysis before maintenance work is performed.

Causal Factor – The conveyor belt was spliced together before the counterweight was installed.

Corrective Action - Review tasks that are performed infrequently to identify hazards that may result from work action sequence interruption. The counterweight installation should have been completed before the belt was spliced together. Design changes need to incorporate a safety review to insure such changes do not pose any unforeseen hazards. A job task analysis should be developed to detect hazards and establish safe work procedures before performing maintenance or repair work.

CONCLUSION

With respect to total load weight of 13,370 pounds, it does not appear that either the crane or the rigging was used beyond their design capacity. However, the nylon slings were not used in accordance with the conditions indicated on the manufacturer's tag. The sharp edge corners of the counterweight plates cut through the west side sling first, instantly transferring the load to the east side sling and the frictional interface between the threaded rod and the bottom tube of the counterweight frame, neither of which could support the remaining load. The threaded rod bent and pulled out and the east side strap simultaneously broke, allowing the weights to fall on the victim. The additional force caused by trying to lift the weight stack and feed its protruding bolt through the hole may have contributed to the cutting of the slings.

A task analysis had not been conducted to identify possible hazards and establish safe procedures to follow when installing the counterweight.

The difficulty posed by attempting to align and secure the counterweight ends was unexpected and resulted in the victim positioning himself under the

suspended load to drive the connecting rod into position. Failure to protect the nylon straps from damage caused by the edges of the steel plates contributed to the accident cause.

ENFORCEMENT ACTIONS

Order No. 6142021 was issued on March 25, 2003, under Section 103(k) of the Mine Act:

> A fatal accident occurred at this operation on March 24, 2003, when a miner was attempting to secure a hoisted gravity take-up pulley weight. This order is issued to assure the safety of persons at this operation and prohibits any work around the decline conveyor gravity take-up and P&H 15 ton crane, until MSHA determines that it is safe to resume normal operations as determined by an authorized representative of the Secretary of Labor. The mine operator shall obtain approval from an authorized representative for all actions to recover and/or restore operations in the affected area.

This order was terminated on March 28, 2003, after the conditions that contributed to the accident no longer existed.

Citation No. 6155739 was issued on April 16, 2003, under Section 104(d)(1) of the Mine Act for violation of 30 CFR 57.16009:

> A fatal accident occurred on March 24, 2003, at this operation when a supervisor was struck by a conveyor belt counterweight that was being installed. The victim was positioned under the suspended counterweight using a hammer to guide a hanger bolt into position when the nylon rigging straps failed. Failure to establish a procedure to install the counterweight in a manner that would not require a miner to be positioned under the suspended load to align the attachment bolts constitute more than ordinary negligence and is an unwarrantable failure to comply with a mandatory standard.

This citation was terminated on June 26, 2003, after the mine operator devised a method to install the counterweight that ensured persons would be clear of suspended loads. All personnel were re-instructed to stay clear of suspended loads.

Citation No. 6155740 was issued on April 16, 2003, under Section 104(a) of the Mine Act for violation of 30 CFR 57.16007b:

> A fatal accident occurred on March 24, 2003 at this operation when a supervisor was struck by a conveyor belt counterweight that was being installed. Nylon rigging straps had been used to support the load, which consisted of 14 rectangular plates of steel that weighed

about 960 pounds each. The edges of the plates had sharp 90-degree angles, which bore on the nylon straps, causing them to fail. These unprotected nylon slings were not suitable for this load with sharp edges. Labels on the slings warned persons to “Avoid sharp edges or rough loads” and to “Protect webbing from sharp edges”.

This citation was terminated on June 26, 2003, after the mine operator devised a method to install the counterweight that ensured the use of proper rigging. All personnel received rigging safety training on April 22, 2003, from a manufacturer of industrial rigging.

Approved By: Date:

Felix A. Quintana
District Manager
North Central District

APPENDIXES

A. Persons Participating in the Investigation

B. Persons Interviewed

C. Photograph of Broken Slings

D. MSHA Forms 7000-50a, b and c (Accident Investigation Data)

APPENDIX A

Persons Participating in the Investigation

Joliet Sand & Gravel Company

Robert Archibald	vice president
George L. Comerford III	surface superintendent
Donald D. Brumm II	underground superintendent
Dan P. Foltyniewicz	risk manager

Patton Boggs LLP, Attorneys at Law

Willa B. Perlmutter	attorney

Mactec Engineering and Consulting Inc.

H. John Head, P.E.	senior principal engineer

Will County Sheriff's Office

Juliann Budde	deputy, evidence

Mine Safety and Health Administration

Fred H. Tisdale	mine safety and health inspector
Stephen W. Field	mine safety and health specialist
Terence M. Taylor	senior civil engineer
Steven J. Vamossy	civil engineer
Leland R. Payne	mine safety and health specialist
Christine M. Kassak	attorney

APPENDIX B

Persons Interviewed

Joliet Sand & Gravel Company

Kevin T. Appleton	maintenance
Mike H. Campbell	maintenance

Appendix C